

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
26 June 2003 (26.06.2003)

PCT

(10) International Publication Number
WO 03/051686 A1

(51) International Patent Classification⁷: **B60R 21/32**,
21/00, 21/01

(21) International Application Number: PCT/IB02/05233

(22) International Filing Date:
10 December 2002 (10.12.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2001-385050 18 December 2001 (18.12.2001) JP

(71) Applicant (for all designated States except US): **TOYOTA JIDOSHA KABUSHIKI KAISHA** [JP/JP]; 1, Toyota-cho, Toyota-shi, Aichi-Ken 471-8571 (JP).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **KACHU, Ryotaro** [JP/JP]; c/o Toyota Jidosha Kabushiki Kaisha, 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-8571 (JP).

(81) Designated States (*national*): AE, AG, AI, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GI, GM, GR, GU, HD, IL, IN, IS, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

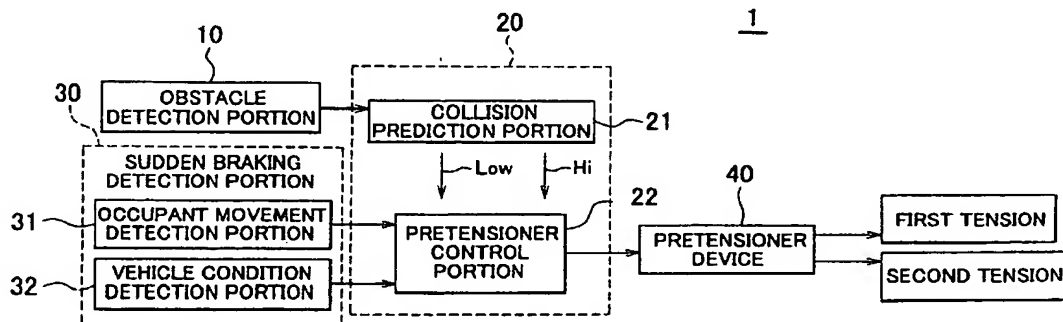
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SI, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CI, CG, CL, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

--- with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SEAT BELT DEVICE AND SEAT BELT DEVICE CONTROL METHOD



(57) Abstract: A seat belt device (1) including an obstacle detection for detecting an obstacle in an area surrounding a vehicle, a collision prediction portion (21) for predicting a probability of a collision between the vehicle and the obstacle based on a detection signal from the obstacle detection portion, a pretensioner device (40), and a pretensioner control portion (22) which controls, when a collision prediction is received from the collision prediction portion (21), the operation of the pretensioner device (40) such that seat belt is retracted prior to the collision. Multilevel tensions for retraction of the seat belt are set for the pretensioner device (40), and furthermore, the tension of the seat belt can be changed by the pretensioner control portion (22) in accordance with a collision prediction level determined by the collision prediction portion (21).



WO 03/051686 A1

SEAT BELT DEVICE AND SEAT BELT DEVICE CONTROL METHOD

BACKGROUND OF THE INVENTION1. Field of Invention

5 The invention relates to a so-called seat belt device with pretensioner for automatically retracting a seat belt. In particular, the invention relates to a seat belt device that retracts a seat belt as a precaution prior to a collision immediately after a vehicle collision is predicted, in order to reliably protect an occupant.

2. Description of Related Art

10 Numerous proposals have been offered related to pretensioner seat belt devices that automatically retract a seat belt during a vehicle collision, in order to protect an occupant with a greater degree of safety. For the pretensioner mechanism, devices have been widely known in which the seat belt is retracted at one stroke under great tension using an explosive or a spring, when the collision is detected.

15 In addition, recently, a number of suggestions have been put forward concerning pretensioner devices which prepare for a collision by retracting the seat belt as a precaution when a collision is predicted. In pretensioner devices that operate precautionarily in this manner, the seat belt is, for example, retracted at a predetermined tension by a motor, or the like. In seat belt devices adopting these
20 pretensioner devices which retract the seat belt as a precaution prior to a predicted collision, the motor, or the like, is stopped and a normal state is returned to if the collision is avoided following prediction. Accordingly, the operation of such pretensioner devices is reversible, thus making them easy to use as compared to devices that utilize a nonreversible method such as an explosive, or the like.

25 A pretensioner seat belt device such as this, which retracts a seat belt as a precaution when a vehicle collision is predicted, is disclosed, for example, in Japanese Patent Laid-Open Publication 2001-247008. In the disclosed seat belt device, if a collision is predicted, a pretensioner device is operated while adjusting the tension at which the seat belt is retracted in accordance with the acceleration of the vehicle.

30 However, in this seat belt device, the seat belt is retracted with a fixed force (tension) if a collision is predicted, regardless of the state of the occupant within the vehicle.

Moreover, there is a high probability of a vehicle collision occurring following the prediction of a collision. However, it is possible to avoid some collisions through

vehicle maneuvers by the driver. In these cases, if the driver is tightly restrained by the seat belt, a detrimental impact is exerted on the ability of the driver to execute breaking and steering operations. As a result, it is conceivable that some accidents occur which could have been avoided through driver vehicle maneuvers following prediction of the collision. In addition, there are also occasions when another occupant of the vehicle feels discomfort due to being excessively restrained by the respective seat belt.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a seat belt with a pretensioner and a control method thereof that can reliably provide improved occupant protection prior to a collision or at times of sudden braking. This is achieved by suitably adjusting the tension of the seat belt in accordance with the probability of a collision actually occurring, when a collision is predicted or sudden braking is detected.

In order to realize the above object, a seat belt device according to an aspect of the invention includes obstacle detection means for detecting an obstacle in the area surrounding a vehicle, collision predicting means for predicting the probability of a collision between the vehicle and the obstacle based on a detection signal from the obstacle detection means, a pretensioner device, and a pretensioner control portion for controlling the operation of the pretensioner device such that the seat belt is retracted when a collision prediction is received from the collision prediction means. Multilevel tensions for retracting the seat belt are set for the pretensioner device, and furthermore, the pretensioner control portion can change the tension of the seat belt in accordance with a collision prediction level determined by the collision prediction means.

Moreover, according to the configuration of the seat belt device described above, the pretensioner control portion can change the tension at which the pretensioner device retracts the seat belt, in accordance with a collision prediction level determined by the collision prediction means. In particular, according to the invention, following a vehicle collision prediction, the force by which the occupant of a seat is restrained by the seat belt is changed prior to the expected collision, in accordance with the probability of the collision occurring. In the case that the probability of the collision occurring is relatively low, namely, when a low collision

prediction level is determined, the tension of retraction is lower, thus enabling the occupant of the seat to continue acting freely. Accordingly, following the prediction of the collision, it is possible for the driver of the vehicle to smoothly execute vehicle steering operations in order to avoid the collision, while preparations for the
5 imminently expected collision are also executed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing a schematic outline of a seat belt device according to an embodiment of the invention;

10 FIG. 2 shows an example of a circuit configuration which can be applied to the seat belt device according the embodiment of the invention; and

FIG. 3 is a flow chart showing an example of a routine executed by an electronic control unit.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Hereinafter, an embodiment according to one aspect of the invention will be described with reference to the drawings.

FIG. 1 is a block diagram showing a schematic outline of a seat belt device according to the embodiment. A seat belt device 1 according to the embodiment
20 includes an obstacle detection portion 10 as obstacle detection means, or the like. This obstacle detection portion 10 detects an obstacle that the vehicle may potentially collide with. A detection signal from the obstacle detection portion 10 is supplied to a control portion 20.

The control portion 20 includes a collision prediction portion 21 as collision
25 prediction means, or the like. This collision prediction portion 21 executes collision prediction following receipt of the detection signal from the obstacle detection portion 10. Furthermore, this control portion 20 also includes a pretensioner control portion 22 as pretensioner control means, or the like. This pretensioner control portion 22 controls the operation of a pretensioner device 40 and changes a tension of the seat
30 belt using the pretensioner device 40.

Moreover, the seat belt device 1 is equipped with a sudden braking detection portion 30 as sudden braking detection means, or the like. This sudden braking detection portion 30 detects a state of sudden braking, when a vehicle suddenly brakes. The sudden braking detection portion 30 detects the state of sudden braking

from the position of the occupant and the condition of the vehicle, using an occupant movement detection portion 31 as occupant movement detection means, or the like and a vehicle condition detection portion 32 as vehicle condition detection means, or the like. The occupant movement detection portion 31 detects, at the least, whether the occupant of the vehicle have plunged forward. The vehicle condition detection portion 32 detects whether the vehicle has tilted forward.

It is possible to use a number of different types of sensors which can detect obstacles existing in the area surrounding the vehicle that are a potential cause of a collision as the vehicle progresses forward, as the obstacle detection portion 10. However, it is desirable that a millimeter wave sensor be used. It is possible to detect relative distance and relative speed of a vehicle with respect to obstacles, by utilizing a millimeter wave sensor. If this millimeter wave sensor is provided in the front bumper of the vehicle, or a similar location, the obstacle detection portion 10 becomes able to detect obstacles in front of the vehicle. Moreover, a plurality of millimeter wave sensors may be provided instead of just one sensor. In the case that a plurality of millimeter wave sensors are provided, it is possible to improve the accuracy at which collisions are predicted through multilevel collision prediction, by simultaneously providing sensors having different detection ranges. For example, it is possible to simultaneously provide and utilize, as the obstacle detection portion 10, a millimeter wave sensor for detecting obstacles that are comparatively far away, and a millimeter wave sensor for detecting obstacles that are extremely close.

Furthermore, the collision prediction portion 21 executes collision prediction based on the detection signal from the obstacle detection portion 10. At this time, the collision prediction portion 21 executes collision prediction such that a predicted collision is classified into a level according to the probability of an actual collision occurring. In other words, the collision prediction portion 21 executes collision prediction by classifying a predicted collisions into one of a low collision prediction level and a high collision prediction level. More particularly, the low collision prediction level indicates a prediction that there is a high chance that a collision with an obstacle will occur, although, this collision may be avoided by vehicle maneuvers following detection. However, the high collision prediction level indicates a prediction that a collision between the vehicle and the obstacle is unavoidable.

For example, in the case that the millimeter wave sensors with different detection ranges are utilized in the obstacle detection portion 10, as previously

described, it is possible to execute collision prediction in the following manner; when an obstacle is detected, if only the comparatively long distance millimeter wave sensor detects the obstacle, a low collision prediction level is determined; and, when the short range millimeter wave sensor detects the obstacle, a high collision prediction level is determined. More particularly, the collision prediction portion 21 obtains the relative distance and relative speed of the vehicle with respect to the obstacle from the outputs of the millimeter wave sensors, refers to the vehicle speed, and executes collision prediction by determining a low collision prediction level or a high collision prediction level.

Furthermore, one millimeter wave sensor or one type of millimeter wave sensor may be used as the obstacle detection portion 10. In this case, collision data is obtained in advance through executing tests and simulations of vehicle and obstacle collisions, and the like, and this data is manipulated into collision prediction data and stored on a ROM, or the like. In addition, the collision prediction portion 21 may execute collision prediction and determine a low collision prediction level or a high collision prediction level through comparison of this collision prediction data and the actual millimeter wave data from the millimeter wave sensor.

Furthermore, the pretensioner control portion 22 receives a collision prediction signal which indicates one of a low collision prediction level and a high collision prediction level from the collision prediction portion 21, and executes operational control of the pretensioner device 40 based on this collision prediction signal. Furthermore, the pretensioner control portion 22 and the collision prediction portion 21 in the seat belt device 1 are realized using an electronic control unit (hereinafter referred to as "ECU").

Moreover, the pretensioner device 40, is installed in a seat belt device having a normal configuration, and retracts the seat belt using a driving source such as a motor. This pretensioner device 40 can adopt the same fundamental configuration as arts that are widely known. However, the pretensioner device 40 of the embodiment specifically adopts a configuration that permits changes of tension in a multilevel manner. As a result, if, for example, the pretensioner control portion 22 regulates the voltage supplied to the motor, the seat belt tension generated by the pretensioner device 40 can be set to one of a first tension (low) in which the seat belt has a degree of slack, and a second tension (high) where the body of the occupant is restrained.

In other words, the pretensioner control portion 22 controls the operation of the pretensioner device 40 such that when the collision prediction of the collision prediction portion 21 is a low collision prediction level the tension is set to the first tension, and when the prediction is a high collision prediction level the tension is set to the second tension.

As previously described, in the seat belt device 1 according to this embodiment, the tension of the pretensioner device 40 is changed in accordance with prediction levels indicating different collision probabilities, which are based on the detection signal from the obstacle detection portion 10. If the collision prediction level predicted by the collision prediction portion 21 is low and there is a possibility that the vehicle can avoid the collision, the seat belt is retracted at a lower tension in which the seat belt has a degree of slack, in other words, a limited degree of slack which allows a driver to move. As a result, the driver can smoothly execute breaking and steering operations in order to avoid the collision. Accordingly, it is possible to execute potential countermeasures for avoiding a collision that can be avoided after collision prediction, while also promoting occupant protection.

From the foregoing description, it is clearly understood that according to the seat belt device 1 of this embodiment, the obstacle detection portion 10 and the control portion 20 make it possible to provide occupant protection since the pretensioner device 40 can be operated in a more advantageous manner after the collision prediction.

In addition, the configuration of the seat belt device 1 according to the embodiment may be further improved by including the sudden braking detection portion 30. This improvement is achieved by focusing attention on the fact that when the vehicle is potentially going to collide with an obstacle, the vehicle enters a sudden braking state due to sudden braking operations executed by the driver. This vehicle sudden braking state is also subject to seat belt tension setting. Namely, with the seat belt device 1, when the vehicle is in a sudden braking state it is assumed that there is a possibility of a collision. Accordingly, the detection of a sudden braking state is one criterion used in changing the tension of the pretensioner device.

The sudden braking detection portion 30 includes the occupant movement detection portion 31 as the occupant movement detection means, or the like and the vehicle condition detection portion 32 as the vehicle condition detection means, or the like. As the occupant movement detection portion 31, it is possible to use a variety of

types of conventional sensor for detecting whether the occupant of the vehicle has plunged forward. Moreover, as vehicle condition detection portion 32, it is possible to use a variety of types of sensor which can detect whether the vehicle has suddenly tilted forward. Particular examples of these sensors will be described hereinafter.

5 As shown in FIG. 1, a sudden braking detection signal from the sudden braking detection portion 30 which is based on detection signals from the occupant movement detection portion 31 and the vehicle condition detection portion 32, is supplied to the pretensioner control portion 22, like the aforementioned collision prediction signal (low or high) from the collision prediction portion 21, and is used in
10 operational control of the pretensioner device 40.

More specifically, this sudden braking detection signal is used as an OR condition for the case where the seat belt is retracted at the aforementioned first tension (low). The reason for this is that a situation in which the driver has seen an obstacle and has suddenly depressed the brake, or the like, can be regarded as having
15 substantially the same level of collision probability as the aforementioned case in which the comparatively long range millimeter wave sensor detected an obstacle. Furthermore, it can be assumed that when the vehicle has approached close enough to an obstacle for it to be detected on the short range millimeter wave sensor, the driver has failed to see the obstacle due to driving inattentively, falling asleep, or the like.
20 Accordingly, the criterion for setting the second tension (high) is based on the signal from the millimeter wave sensor which detects obstacles at close range.

On the other hand, when an obstacle in front of the vehicle is far off, it is difficult to detect the obstacle using the millimeter wave sensor. However, it is conceivable that the obstacle enters into the field of vision of the driver and is
25 recognized, and thus the driver brakes. In such a case, if the sudden braking detection portion 30 is also installed as in the embodiment, it is possible to infer that a collision may happen from the sudden braking state of the vehicle, which makes it possible to operate the pretensioner device more effectively.

FIG. 2 shows an example of a circuit configuration that can be used in the seat
30 belt device 1. In FIG. 2, millimeter wave sensors are utilized as the obstacle detection portion 10. In addition, a number of concrete examples are given of the sensor detections of the occupant movement detection portion 31 and the vehicle condition detection portion 32 included in the sudden braking detection portion 30. Furthermore, the control portion 20 of FIG. 1 is realized using the ECU which

controls the entire seat belt. In FIG. 2, all of the portions other than the millimeter wave sensor (obstacle detection portion) 10, the sudden braking detection portion 30 and the pretensioner device 40 are included in the ECU.

5 In FIG. 2, as the occupant movement detection portion 31, a plurality of sensors are provided for detecting the movement of the occupant inside the vehicle. These sensors detect whether the occupant of a seat has plunged forward based on the shift in load of the occupant. For example, as shown in FIG. 2, the shift in load of the occupant when moving toward the front portion of the seat is detected by a pressure sensor disposed beneath the seat of the occupant. Moreover, the shift in load of the
10 occupant when moving toward the front of the vehicle is detected by a pressure sensor disposed beneath the feet of the occupant. In addition, the shift in load of the driver when moving toward the front of the vehicle is also detected by a pressure sensor disposed in the steering wheel. These detection signals related to the occupant are supplied to an AND circuit 52 via an OR circuit 51.

15 Moreover, as the vehicle condition detection portion 32, a plurality of sensors are provided for detecting whether the vehicle has suddenly tilted forward. For example, as shown in FIG. 2, the strength of a depression force is detected by a pressure sensor for detecting depression of the brake pedal. In addition, the movement of the vehicle in an upward or downward direction is detected by a G
20 sensor for detecting upward and downward direction deceleration of the suspension, and, the state of forward tilt is detected by a sensor for detecting changes in the height of the vehicle at its front and the back. Furthermore, these sensors may detect the brake pedal depression force by referring to the operation signals from the brake assist (BA).

25 The aforementioned detection signals related to the vehicle are, unlike the detection signals related to the occupant, supplied directly to the AND circuit 52. In the case of the detection signals related to the occupant, if it is possible to detect that the occupant has plunged forward using any one of the sensors, it is inferred that the vehicle is in a sudden braking state.

30 However, in the case of the detection signals related to the vehicle, it cannot be inferred with a high degree of certainty that the vehicle is in a sudden braking state, based on the detection signal from only one sensor. This is because of situations such as when the vehicle is travelling along a slope, or along a rough road where the vehicle moves up and down substantially. As a result, it is determined that the vehicle

has suddenly tilted forward only when all of the sensors related to the vehicle are in an ON state. Furthermore, among all of the detection signals, the depression force of the brake pedal most accurately reflects the fact that vehicle is in a sudden braking state. Thus, if only one detection sensor related to the vehicle is used as the vehicle
5 condition detection portion 32, it is preferable that the sensor for detecting the depression force of the brake pedal be adopted.

Accordingly, if any one of the sensors for detecting movement of the occupant is ON or, if all of the sensors for detecting forward tilt of the vehicle are ON in the AND circuit 52, the ECU will determine that the vehicle is in a sudden braking state.
10 In addition, as previously described, this sudden braking detection signal is supplied to the OR circuit 53, which is one of the criterion for the pretensioner device to retract the seat belt at the first tension (low).

In addition, the obstacle detection portion 10 sends a detection signal in accordance with the location of the detected obstacle. The collision detection portion
15 of the ECU determines whether the collision prediction is a low collision prediction level or a high collision prediction level, based on the detected signal. If the prediction is a low collision prediction level, the signal is supplied to the Or circuit 53. As a result, when there is at least one of a sudden braking detection signal or a low collision prediction level prediction, the ECU which functions as the pretensioner
20 control portion, executes control of the pretensioner device 40 such that the seat belt is retracted at the first tension (low).

Alternatively, if the collision prediction portion predicts a high collision prediction level, the ECU executes control of the pretensioner device 40 such that the seat belt is retracted at the second tension (high). Furthermore, if sudden braking is
25 detected when a high collision prediction level is determined, the ECU gives priority to the high collision prediction level and executes control of the pretensioner device 40 such that the seat belt is retracted at the second tension (strong).

In addition, hereinafter, an example will be described of the processing executed after collision prediction by the ECU that functions as the collision
30 prediction portion 21 and the pretensioner control portion 22 in the seat belt device 1 according to the embodiment. FIG. 3 is a flow chart showing an example of a routine executed by the ECU.

In FIG. 3, the ECU processes the millimeter wave data periodically detected by the obstacle detection portion 10 (step S100), and monitors whether there is a

possibility of a vehicle collision occurring (step S102). If a collision is not predicted in step S102, it is confirmed whether the vehicle is in a state of sudden braking (step S104). In the case that sudden braking of the vehicle is detected in step S104, the ECU sets the pretensioner device to the first tension (low) (step S110), operates the pretensioner device, and completes processing according to the routine. In the case that sudden braking of the vehicle is not detected in step S104, the ECU returns to collision monitoring based on the millimeter wave data.

If it is predicted that a collision is possible in step S102, it is determined whether the collision prediction should be a high collision prediction level or not, based on the detection signal from the millimeter wave sensor (step S106). If a high collision prediction level is determined in step S106, the ECU sets the pretensioner device to the first tension (low), operates the pretensioner device and completes processing according to the routine.

Alternatively, if the collision prediction level determined in step S106 is not high, the ECU infers that the collision prediction level is low, and thus sets the pretensioner device to first tension (low) (step S110), operates the pretensioner device and completes processing according to the routine.

In the described embodiment, as an example, collision prediction is classified into two prediction levels. However, the invention is not limited to this, and may be realized with three or more prediction levels. Furthermore, the tension set for the pretensioner device may also be divided into three levels or more in accordance with the number of prediction levels.

Furthermore, in this embodiment, when there is a collision prediction by the obstacle detection portion 10 and the collision prediction portion 21, detection of the sudden vehicle braking state by the sudden braking detection portion 30 is used as a complimentary criterion for the setting of the tension of the pretensioner device 22. However, it is possible to configure the pretensioner device 22 such that seat belt retraction is only based on the sudden braking detection of the sudden braking detection portion 30. By doing so, the seat belt device can provide occupant protection with a simpler configuration.

A preferred embodiment of the invention has been described above. However, the invention is not limited to this embodiment which is to be considered in all respects as illustrative and not restrictive. The scope of the invention is indicated by

the appended claims, and all changes that come within the meaning and range of equivalency of the claims are intended to be embraced therein.

From the foregoing description, it is clearly understood that, according to the invention of the first aspect, when the collision prediction level is low, that is, the probability of a vehicle collision is comparatively low, the tension of the seat belt is set to a lower tension so that a state in which the occupant can act freely is maintained. Accordingly, following the prediction of the vehicle collision, the driver is able to smoothly execute vehicle maneuvers in order to avoid the collision. However, at the same time, preparations for the imminently expected collision can also be executed.

If there is a possibility of avoiding a collision when a collision is predicted, it is possible to use a first tension. However, if there is no possibility of avoiding the collision, it is possible to use a second tension. Accordingly, at the collision prediction stage, it is possible to change the tension of the seat belt in accordance with collision probability, so that the tension of the seat belt is optimal for the occupant of the seat.

Furthermore, it is possible to set a seat belt tension that is optimal for occupant protection, in accordance with different collision prediction levels having different collision probabilities.

Moreover, the sudden braking state of the vehicle is also taken into consideration when adjusting the tension of the seat belt, thus allowing occupant protection to be executed even more reliably.

In addition, the pretensioner device is operated by the pretensioner control portion which receives a signal from a sudden braking detection means that detects if the vehicle has suddenly tilted forward. As a result, according to the invention, occupant protection can be improved by retracting the seat belt as a precaution.

Furthermore, the invention focuses on the fact that, generally, when the driver anticipates that a collision will occur, there is a reasonable amount of time until the collision will actually take place. Thus, if collision avoidance maneuvers are continued during this time, many collisions can be avoided. As a result of the seat belt being retracted at the comparatively low first tension when the sudden braking of the vehicle is detected, such collision avoidance maneuvers can be continued.

Moreover, it is possible to reliably detect whether the vehicle is in a sudden braking state by referring to the position of the occupant and the condition of the vehicle.

Claims:

1. A seat belt device characterized by comprising:

an obstacle detection portion that detects an obstacle in an area
5 surrounding a vehicle;

a collision prediction portion that predicts a probability of a collision of
the vehicle with the obstacle, based on a detection signal from the obstacle detection
portion;

a pretensioner device that set with multilevel tensions retracting of a seat
10 belt; and

a pretensioner control portion that controls, when the collision prediction
from the collision prediction portion is received, an operation of the pretensioner
device such that the seat belt is retracted prior to the collision at a tension in
accordance with a collision prediction level determined by the collision prediction
15 portion.

2. The seat belt device according to claim 1, characterized in that

the pretensioner device is set to one of a first tension in which the seat belt
has a limited degree of slack which allows an occupant of a seat to move, and a
20 second tension which is higher than the first tension and where a body of the occupant
of the seat is restrained.

3. The seat belt device according to claim 2, characterized in that

the collision prediction portion detects one of a low collision prediction
25 level indicating that there is a possibility that the vehicle may avoid the collision, and
a high collision prediction level indicating that the vehicle collision is unavoidable,

based on a state of the detection signal from the obstacle detection portion; and

the pretensioner control portion that controls the pretensioner device such that, if the collision prediction portion predicts the low collision prediction level then the seat belt is retracted at the first tension, and if the collision prediction portion predicts the high collision prediction level then the seat belt is retracted at the second tension.

4. The seat belt device according to claim 3, characterized by further comprising:

a sudden braking detection portion that detects a state of sudden braking of the vehicle, in that

the pretensioner control portion controls the pretensioner device such that the seat belt is retracted at the first tension when, at least, one of the collision prediction portion predicts the low collision prediction level, and the sudden braking detection portion detects a vehicle sudden braking.

5. A seat belt device characterized by comprising:

a sudden braking detection portion that detects a state of sudden braking of a vehicle;

a pretensioner device that is set to one of a first tension in which a seat belt has a limited degree of slack which allows an occupant of a seat to move, and a second tension which is higher than the first tension and where a body of an occupant of a seat is restrained; and

a pretensioner control portion that controls an operation of the pretensioner device, such that the seat belt is retracted at the first tension when it is detected by the sudden braking detection portion that the vehicle is in a sudden braking state.

6. The seat belt device according to claims 4 or 5, characterized in that
the sudden braking detection portion includes an occupant movement
detection portion that detects that an occupant of the vehicle has plunged forward, and
5 a vehicle condition detection portion that detects that the vehicle has suddenly tilted
forward.
7. The seat belt device according to claim 6, characterized in that
the occupant movement detection portion is a sensor that detects a state of
10 forward plunge of the occupant, based on a shift in load of the occupant with respect
to a specific location in the vehicle.
8. The seat belt device according to claim 6, characterized in that
the vehicle condition detection portion is a sensor that detects that the
15 vehicle has suddenly tilted forward, based on at least a depression force of a brake
pedal.
9. The seat belt device according to claim 2 or 5, characterized in that
a larger amount of electric power is supplied to a motor for seat belt
20 retraction when the seat belt is retracted at the second tension than when the seat belt
is retracted at the first tension.
10. A seat belt control method characterized by comprising the step of:
detecting an obstacle in an area surrounding a vehicle;
25 predicting a probability of the vehicle colliding with the obstacle;
determining a level of the predicted collision;

selecting a tension from among preset multilevel tensions at which a seat belt is retracted, in accordance with a result of the collision prediction level determination; and

retracting the seat belt at the selected tension prior to the collision.

5

11. The seat belt control method according to claim 10, characterized in that the tension at which the seat belt is retracted is set to be one of a first tension in which the seat belt has a limited degree of slack which allows an occupant of a seat to move, and a second tension which is higher than the first tension and where a body of an occupant of a seat is restrained.

10

12. The seat belt control method according to claim 11, characterized in that a collision prediction determination has one of a low collision prediction level indicating that there is a possibility that the vehicle may avoid the collision, and a high collision prediction level indicating that the vehicle collision is unavoidable; and

15

the seat belt is retracted at the first tension when the low collision prediction level is predicted, and is retracted at the second tension when the high collision prediction level is predicted.

20

13. The seat belt control method according to claim 12, characterized in that the seat belt is retracted at the first tension when, at least, one of the low collision prediction level is predicted, and a sudden braking of the vehicle is detected.

25

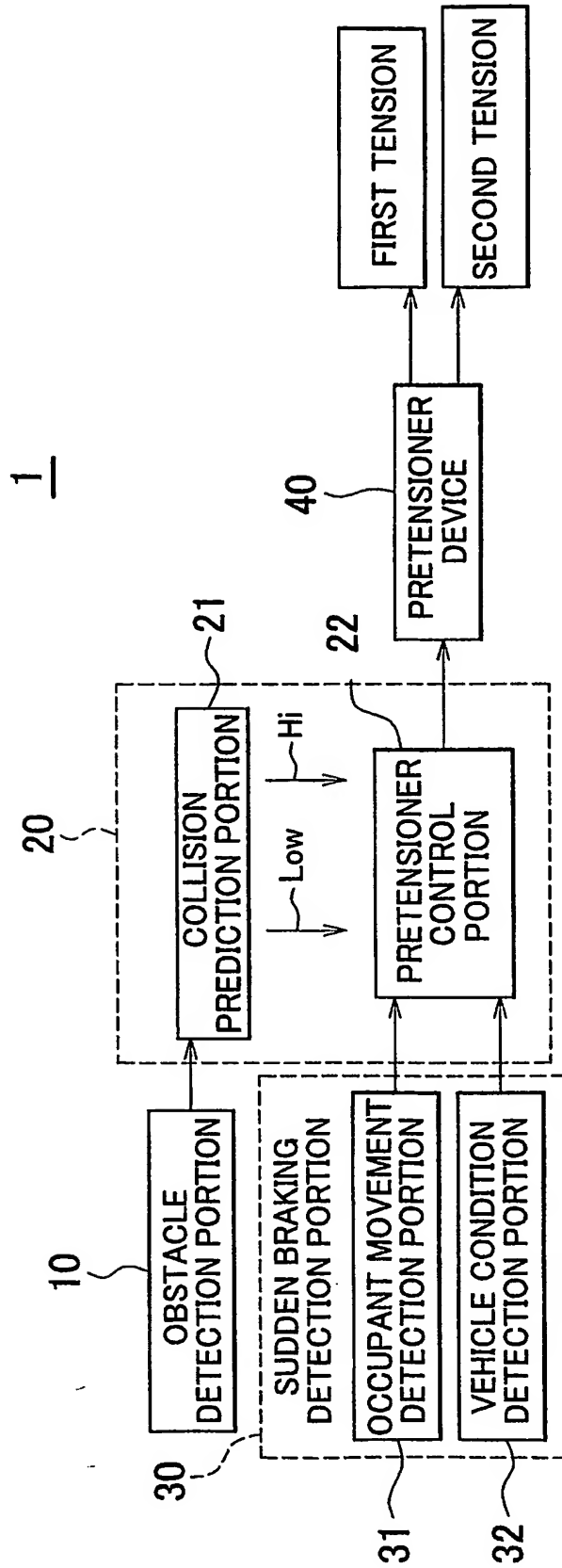
14. The seat belt control method according to claim 13, characterized in that the sudden braking of the vehicle is detected by detecting that an occupant

of the vehicle has plunged forward.

15. The seat belt control method according to claim 11, characterized in that
a larger amount of electric power is supplied to a motor for seat belt
5 retraction when the seat belt is retracted at the second tension than when the seat belt
is retracted at the first tension.

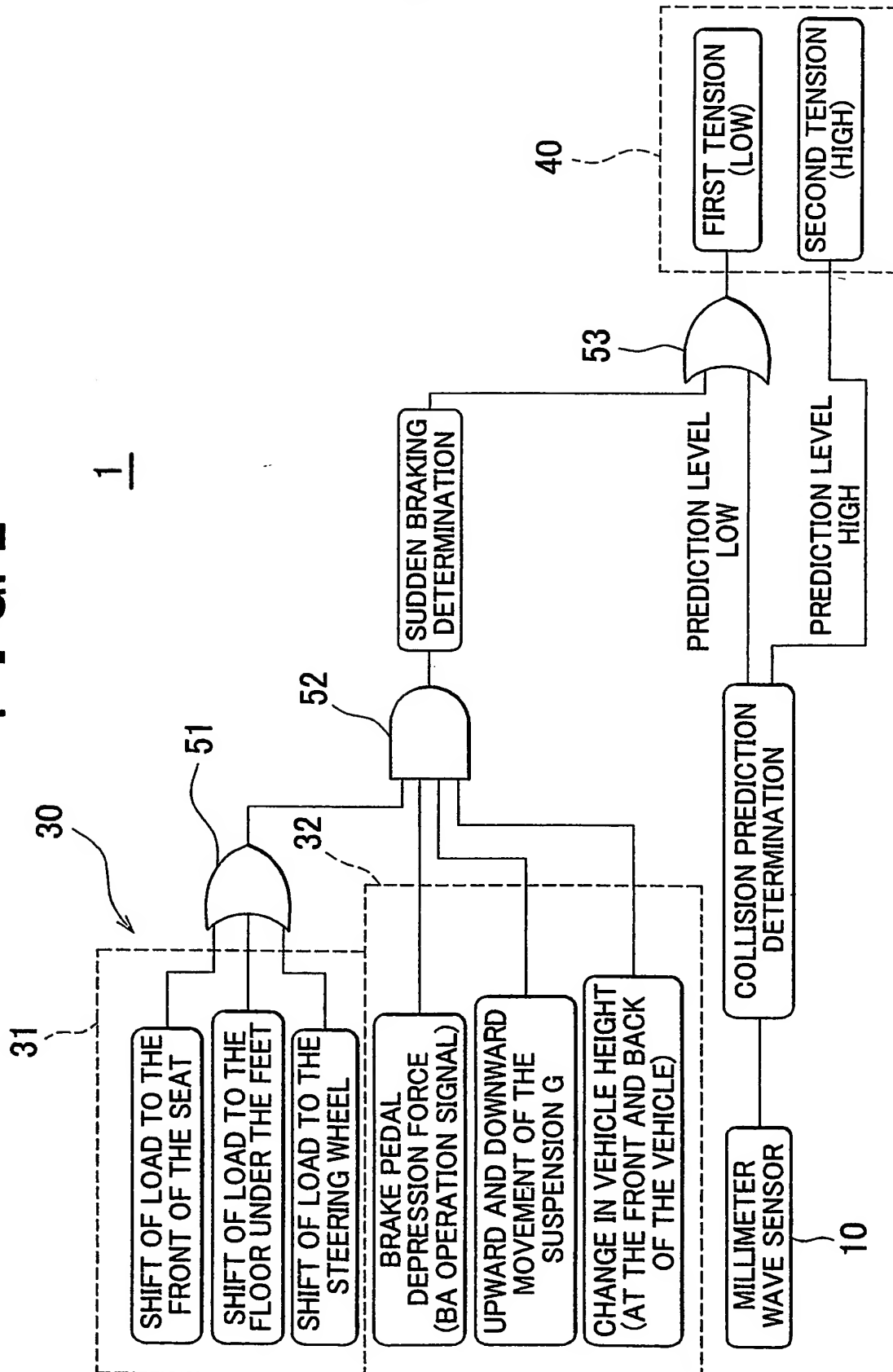
1/3

FIG. 1



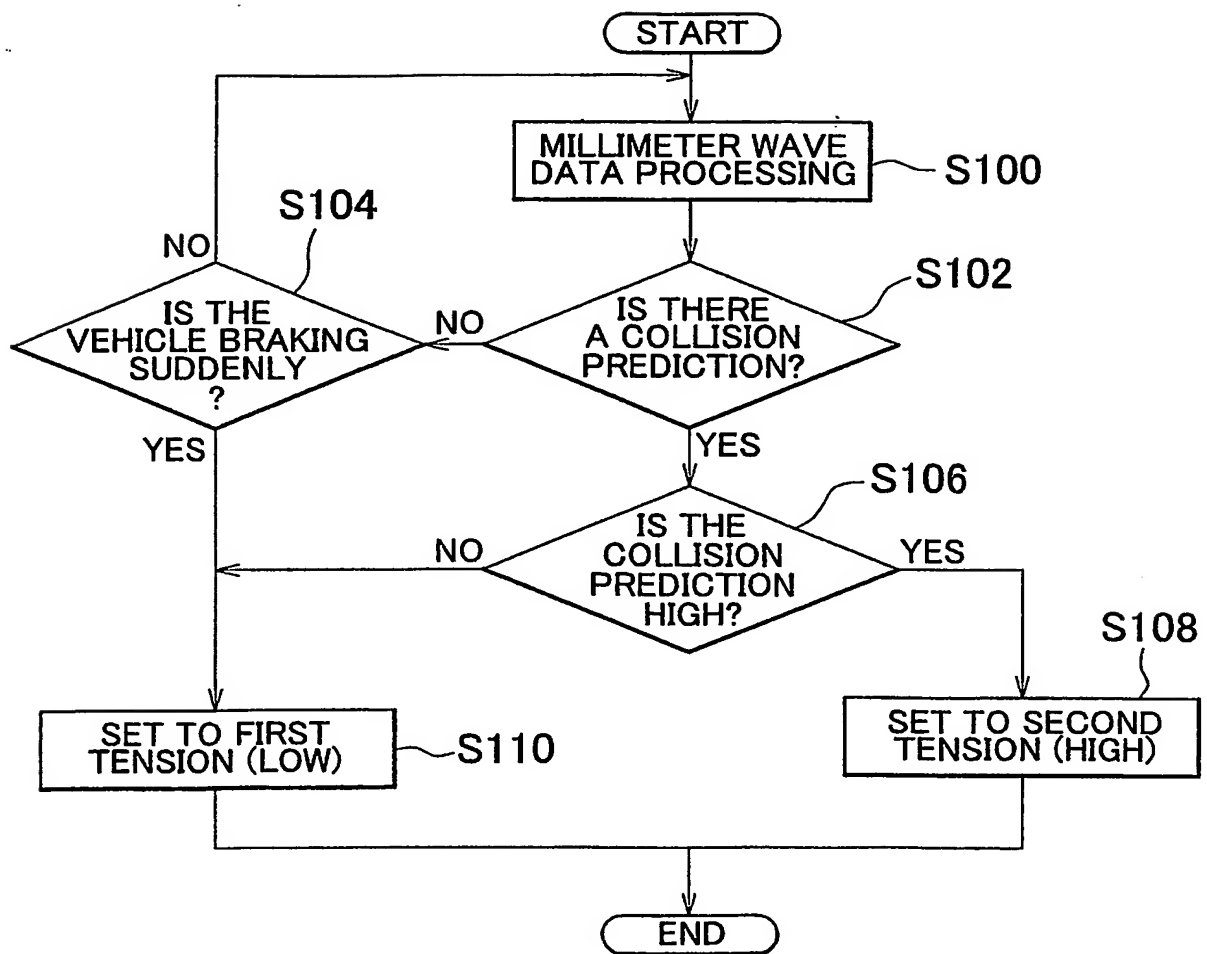
2/3

FIG. 2



3/3

FIG. 3



INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/IB 02/05233

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60R21/32 B60R21/00 B60R21/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 44 11 184 A (NISSAN MOTOR) 6 October 1994 (1994-10-06) abstract; figures 1-30	1-5, 10-13
X	DE 197 39 655 A (BOSCH GMBH ROBERT) 26 November 1998 (1998-11-26) column 1, line 5 - line 25 column 1, line 60 - line 64 column 2, line 20 - line 37 ----- -/--	1, 2, 4, 10, 11, 13, 14



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

Date of the actual completion of the international search

20 March 2003

Date of mailing of the international search report

03/04/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Geuss, H

INTERNATIONAL SEARCH REPORT

Inter. Appl. No.

PCT/IB. 02/05233

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 196 47 660 A (DAIMLER BENZ AG) 20 May 1998 (1998-05-20) abstract column 2, line 21 - line 68 column 4, line 43 - line 56 column 6, line 7 - line 24 column 8, line 49 - line 65 column 9, line 55 - line 60 -----	1-3
A	WELLER J: "Vorausschauende Sensorik fuer zukuenftige Sicherheitssysteme" INNOVATIVER KFZ-INSASSEN- UND PARTNERSCHUTZ. TAGUNG BERLIN, SEPT. 30 - OKT. 1, 1999, VDI BERICHTS 1471, DUESSELDORF: VDI VERLAG GMBH, DE, vol. 471, 30 September 1999 (1999-09-30), pages 229-236, XP002203527 ISBN: 3-18-091471-8 the whole document -----	1-15

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 02/05233

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 4411184	A	06-10-1994	JP 2946995 B2	13-09-1999
			JP 6286581 A	11-10-1994
			DE 4411184 A1	06-10-1994
			US 5552986 A	03-09-1996
DE 19739655	A	26-11-1998	DE 19739655 A1	26-11-1998
			WO 9852794 A1	26-11-1998
			DE 59806730 D1	30-01-2003
			EP 0983168 A1	08-03-2000
			JP 2001525757 T	11-12-2001
			US 6186261 B1	13-02-2001
DE 19647660	A	20-05-1998	DE 19647660 A1	20-05-1998
			EP 0842829 A1	20-05-1998
			JP 10181520 A	07-07-1998
			US 6031484 A	29-02-2000